N73-14431
TR 1198

JOHN F. KENNEDY
SPACE CENTER

AUGUST 19, 1972

CASE FILE
COPY

STUDY TO DEVELOP IMPROVED METHODS TO DETECT LEAKAGE IN FLUID SYSTEMS

PHASE III

BY: J. C. JANUS & I. CIMERMAN
DYNAMATEC CORPORATION

NASA CONTRACT NO. NAS10-7803

NASA Contract No. NAS10-7803

STUDY TO DEVELOP IMPROVED METHODS TO DETECT LEAKAGE IN FLUID SYSTEMS

PHASE III

By: J. C. Janus & I. Cimerman
Dynamatec Corporation
Cocoa Beach, Florida

B. A. Tolson - NASA Project Manager

August 19, 1972

Prepared for

NASA, John F. Kennedy Space Center, Florida

This report was prepared as an account of Government-Sponsored work. Neither the United States, nor the National Aeronautics and Space Administration (NASA), nor any person acting on behalf of NASA:

A) Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately-owned rights; or

B) Assumes any liabilities with respect to the use of, or for damages resulting from the use of, any information, apparatus, method or process disclosed in this report.

As used above, "person acting on behalf of NASA" includes any employee or contractor of NASA, or employee of such contractor, to the extent that such employee or contractor of NASA or employee of such contractor prepared, disseminates, or provides access to any information pursuant to his employment or contract with NASA, or his employment with such contractor.

ACKNOWLEDGEMENTS

This document was prepared by the Dynamatec Corporation. Mr. John C. Janus was the Study Manager and he was assisted by Mr. I. Cimerman. Mr. J. L. Pearce and Mr. Richard A. Gilbert provided valuable assistance throughout the study.

The thermal and altitude chamber support provided by Mr. C. Springfield and Mr. Ben Johnson of NASA, KSC, was very helpful during the test evaluation portion of this contract. Acknowledgement is also made for the valuable technical assistance and guidance provided through the efforts of Mr. Bill A. Tolson, NASA Project Manager, for this study.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

SECTION I

INTRODUCTION

1.1 PURPOSE

The purpose of Contract NAS10-7803, "Study to Develop Improved Methods to Detect Leakage in Fluid Systems - Phase III," was to design and fabricate a prototype flight weight ultrasonic contact sensor leak detection system and to perform the necessary testing to collect enough data to establish design parameters and develop necessary baseline operating characteristics. Development of this flight weight detector was accomplished as a follow-on contract to the Dynamatec Corporation's Phase II study which developed an engineering prototype ultrasonic contact sensor leak detection system and demonstrated its potential under cryogenic conditions.

1.2 SCOPE

The Dynamatec Corporation's contracted statement of work specified that the corporation would:

a) design and fabricate flight weight ultrasonic contact sensors

b) design and fabricate a flight weight supporting electronic package

c) perform an in depth engineering evaluation test program

The flight weight ultrasonic contact sensor system would consist of a minimum of five channels and would be capable of monitoring frequencies from 1 KHz to 110 KHz.

SECTION II

2.1 BACKGROUND

The complete background data leading up to "Study to Develop Improved Methods to Detect Leakage in Fluid Systems - Phase III" can be obtained by reviewing the final reports of the two previous contracts. The first contract titled "Study to Develop Improved Methods to Detect Leakage in Fluid Systems" was a general leak detection requirement study and was documented in the final report under NASA PR No. 1088. The Phase II study was a prototype hardware development contract and the results were documented in NASA PR No. 1130. The Phase III study which is documented in this report was a contract to develop a lightweight unit and to demonstrate that this lightweight unit could be made suitable for flight application.

"Study to Develop Improved Methods to Detect Leakage in Fluid Systems" - the first contract that the Dynamatec Corporation performed for NASA, Kennedy Space Center, was an engineering study to review existing leak detection systems at all NASA centers, at other government and industrial locations and any additional applications of leak detection techniques that could possibly be used for future space programs. A review of all vendor data was accomplished and the latest state-of-the-art studies being performed at various universities were also reviewed. A number of foreign studies dealing with leak detection techniques were also reviewed and numerous discussions were held with prominent people in the leak detection field to determine what other possible means could be utilized for leak detection on future flight systems.

Simultaneous with the review of all state-of-the-art and leak detection systems in research and development, the Dynamatec Corporation contacted key NASA and potential contractor Space Shuttle people to determine the requirements for a leak detection system on the Space Shuttle and other future flight systems. This study covered a review of the requirements for a ground system and for the flight hardware. For use on the ground support systems, four basic systems were identified. These were a hazardous gas detection system which will be mandatory as long as hydrogen or hypergols are in use. The second was an enclosed system where the hazardous GSE is enclosed in a nitrogen purged room which is remotely vented. The third system was ultrasonic contact sensors for use on critical GSE such as quick disconnects and mission essential equipment. The fourth was the standard mass spectrometer which is now being utilized and will be required for leak detection systems which are in the 0 leakage rate due to the hazardous nature of the gases.

For the flight vehicle, two basic leak detection systems appeared to meet the requirements identified earlier. The first was the use of the onboard mass spectrometer which could be used for life support purposes, hazardous gas detection in pressurized areas of the vehicle and for leak detection during ground operation. A mass spectrometer which could be modified to meet this requirement is being developed under NASA contract by the Perkin-Elmer Corporation. The second recommendation was that ultrasonic contact sensors be used for both ground checkout and flight operational monitoring. The advantages of this system are that it will work in vacuum conditions, it can detect internal leaks without breaking into the system, it is extremely lightweight and can be automated to eliminate much of the time required with manual detection systems. In addition to leak detection, it seems promising as a refurbishment information tool since it could identify progressively increasing leaks across valve seats, seals and other internal hardware and provide trend data or failure prediction data as to when a component should be changed out.

Following the completion of the first contract, it was determined by NASA that further investigation into the applications of ultrasonic contact sensors should be accomplished. The Dynamatec Corporation was awarded a hardware development contract for engineering prototype contact sensors and supporting electronics. Five channels of ultrasonic leak detection sensors and electronics were developed during this contract. Since little was documented about leak detection in other ranges than the standard 40 KHz range selected by the ultrasonic microphone type of leak detector, it was decided to investigate all ranges from 0 to 110 KHz. Five channels of electronics and sensors were manufactured with each channel having a set frequency and individual steps from 0 to 110 KHz. The hardware developed consisted of ultrasonic contact sensors developed and manufactured by the Dynamatec Corporation specifically for leak detection, sensitive preamplifiers to amplify the transducer signals, a translation assembly to put out audible sounds, an oscilloscope so that each signal could be analyzed and a digital voltmeter to provide signal levels. The electronics package was capable of putting out analog or digital signals capable of interfacing with a computer or with recording instrumentation.

This prototype ultrasonic contact sensor leak detection system was tested at the KSC cryogenic facility under cryogenic conditions. The five transducers were located on various bare uninsulated liquid hydrogen lines associated with the transfer operation. The system was also tested in the Dynamatec laboratory on valve seat leakage and external leakage through tanks and fittings. It was during this contract that the basic transducer development was accomplished and where the system was proven to be an effective leak detection instrument. In addition to detecting leaks in gaseous or cryogenic systems, the leak detection system also proved to be an effective tool for monitoring phase changes. While mounted on a liquid nitrogen line,

the transducer provided signals which could be easily interpreted to identify gas flow, start of liquid flow, boiling of the cryogenic material, cool down and solid liquid flow. It appears that this application can find usage as a cool down or tanking tool.

SECTION III
PHASE III
SYSTEM DESCRIPTION

3.1 OVERALL SYSTEM

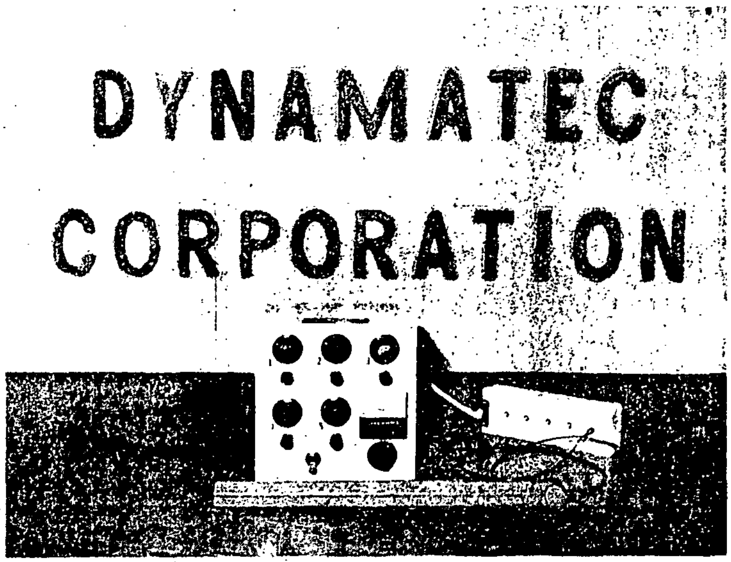
The top picture on page 5a shows the control unit, the cable between the control unit and the preamplifier unit, the preamplifier unit and the transducer and cable feeding out of the preamplifier unit. The size of the equipment is illustrated by the engineering scale in the foreground. The control box is powered by the AC cord that is shown or by a battery pack that plugs into the same receptacle as the AC cord.

3.2 FRONT PANEL

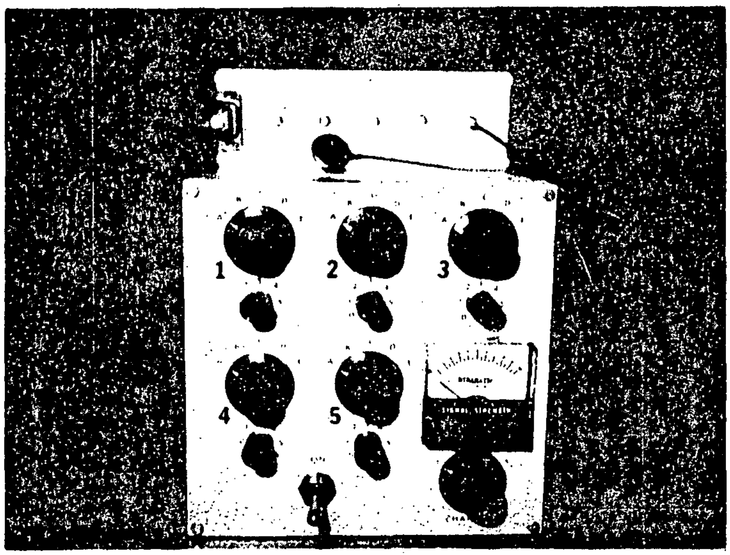
The front panel of the control unit and the preamplifier unit is illustrated in the middle picture on page 5a. The preamplifier unit is shown setting on top of the control unit and is cabled and in operating position. On the extreme left of the picture is the interfacing cable between the control unit and the amplifier unit. This interface cable carries power to the amplifiers and returns the amplified transducer signal to the control unit. The 5 connectors immediately to the right of the interfacing cable are the inputs to the preamplifiers from 5 transducers. One transducer and cable are shown attached to the amplifier unit. The size of the preamplifying unit is 2.5 cm by 5 cm by 15 cm and it contains 1 PC card containing 5 preamplifiers. Immediately below the preamplifying unit is the control unit. The large numbers on the face of the control unit from 1 through 5 are the basic channels and correspond to the 1 through 5 numbers on the preamplifier unit. Two controls are associated with each channel. The controls letters from A through E are those for the variable frequency filter and correspond to the center frequencies listed in the calibration specification. The smaller dial associated with each channel is the gain control which allows strong signals to be reduced to an acceptable level for recording. An on/off switch is located at the bottom of the front panel and controls all electrical power to both the control unit and the preamplifier unit. A meter and a channel selector switch are located on the lower right hand corner of the front panel. The channels 1 through 5 correspond to the 1 through 5 numbers on the preamplifier unit and the 1 through 5 numbers associated with each channel on the front panel of the control unit. Only 1 channel at a time can be selected for display on the meter. This meter is basically a setup tool and is not meant to be the main data source.

3.3 BACK PANEL VIEW

The bottom picture on page 5a shows the back side of the preamplifier box and the back panel of the control unit. The top connector is

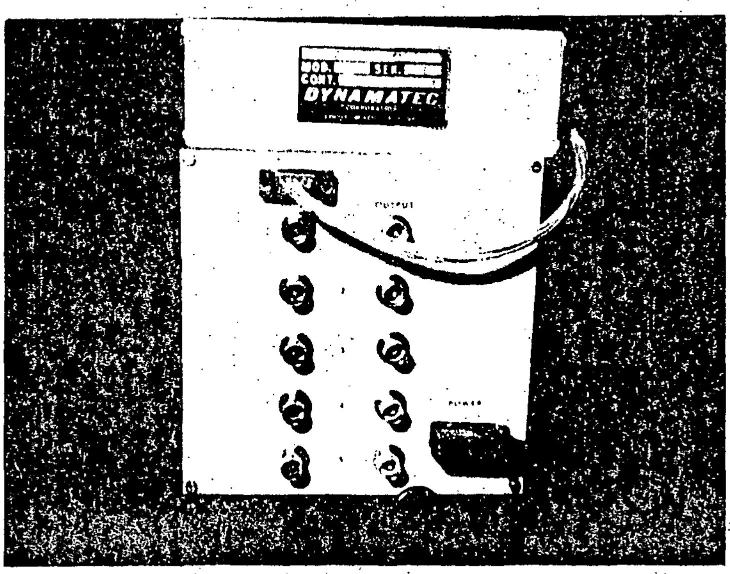


OVERALL
SYSTEM



AMPLIFIER
ON TOP

FRONT
PANEL



BACK PANEL
VIEW

the power to the preamplifiers and the returned amplified signal from the transducers. Immediately below the top connector are 5 connectors for providing raw data recording from the preamplifier box. These are labeled inputs standing for inputs to the control unit. Immediately to the left are 5 connectors labeled 1 through 5 outputs. These 5 connectors provide recording or scope connectors for the analysis of data after it has been processed through the variable frequency filters. These 5 connectors are the basic data recording outputs. In the bottom right hand corner is the AC or battery power input to the control unit.

3.4 EQUIPMENT DESCRIPTION

The flight weight ultrasonic contact sensor leak detection system which was delivered to NASA (Figure No. 1) consisted of 5 ultrasonic contact sensors, connected by coax cables 1 meter long to a signal conditioning unit containing 5 preamplifiers. The preamplifier box was, in turn, coupled to control unit containing 5 tuneable filter subassemblies, 5 gain controls, 10 output jacks, a channel selector switch and a signal level meter. This deviates somewhat from the proposed flight configuration but provides a more suitable development tool.

3.5 FLIGHT VERSION

A typical flight instrumentation version of the ultrasonic contact sensor leak detection system would be as shown in the block diagram of Figure No. 2. The system would be capable of handling a number of contact sensors quasi-simultaneously and would provide, on command, a serial digital representation of the sensor outputs at sequential frequency ranges as selected by the central processor.

Each transducer would have its own preamplifier designed to raise the signal to a level suitable for multiplexing and avoid the problems associated with switching of microvolt signals. The multiplexer would scan all the transducers in sequence or could, on command, select specific transducers in critical areas for more frequent monitoring.

The variable frequency filter receives the output of the multiplexer and band limits the signal over a narrow range with a center frequency determined by an external control voltage. This control voltage is generated by digital to analog conversion of the appropriate bits in the command word received from the central processor. The timing and control section of the system also has the ability to generate a continuously variable control voltage when it is desired to analyze the full frequency spectrum.

The output of the VFF is an analog voltage corresponding to the leak sound amplitude at the instantaneous center frequency. This voltage is then digitized and stored in the buffer register and transferred serially to the central processor.

The assembly that was delivered to NASA was manufactured with 5 frequency filter assemblies and 5 gain controls so that continuous monitoring and recording can be performed on all channels simultaneously. A signal level meter can be switched to any of the 5 channels and is used as a setup tool or as an individual channel monitor if recording is not desired (Figure No. 1.)

The statement of work specified that the leak detection system could operate on either 15 or 30 VDC. A design goal was implemented by the Dynamatec Corporation to develop low power circuits and was successful to the extent that all system power for the unit can be supplied by a small battery. The unit also has the capability of being powered by standard facility 120 VAC power during long duration tests. The flight configuration would interface with spacecraft power but 120 VAC or battery power was selected for the prototype unit since it simplified interfaces and provided a portable unit for test purposes.

A complete sound measuring system (Figure No. 1) consists of the following components:

1. Contact transducers responsive to sound conducted through the solid to which it is attached and having a much lower sensitivity to external sounds conducted through the surrounding medium.

2. A signal conditioning preamplifier permitting a match to the transducer output and sufficient gain to drive following signal processing circuitry.

3. A manual or automatic gain control to limit the input to the filter to an appropriate level.

4. A bandpass filter with controllable center frequency, the frequency control may be either switch selected or continuously variable via a remote control voltage.

5. A buffer or isolation amplifier providing additional gain and a low impedance output to drive a recorder or external displays.

6. A meter drive circuit and indicator to display the relative level of the sound signal. Description of the individual circuits are given below.

3.6 PREAMPLIFIER

The preamplifier assembly contains 5 signal conditioning preamplifiers and is shown in Figure No. 3. The transducer inputs are on Micro Dot connectors on the top plate, signal output and power are on a "D" connector on the same side of the box as the inputs. The

preamplifier circuit is a voltage amplifier used to increase the microvolt level output of the transducer to a level suitable for recording and processing. The load presented to the transducer allows good power transfer without excessive degradation of the frequency response by cable capacitance. The transistors used in this circuit are especially selected for high gain and low noise at a very low collector current. An output emitter follower isolates the circuit and provides a low impedance drive for the level control and the frequency selection filter as well as external displays or recorders through the BNC connector located in the control unit (Figure No. 4).

3.7 FILTERS

Several active filter configurations were considered for use in the system. The requirement for variable frequency operation, especially remotely controlled frequency selection, led to the design of a modified multiple feedback bandpass circuit whose center frequency can be varied without affecting the overall gain.

3.8 BUFFER AMP

The buffer amplifier provides an additional 20 db of gain and serves to isolate the filter from external devices.

3.9 METER DRIVER

The meter driver can be switched to the output of any of the filters. It converts the signal to DC and is biased to conduct only after a predetermined threshold is reached. This prevents the inherent amplifier noise from deflecting the meter when no signal is present and the system gain is maximum.

3.10 TRANSDUCERS

The design goal was to produce an ultrasonic contact sensor with a maximum weight of 7 grams. A number of transducer configurations were developed and tested. These ranged in weight from 2 grams for a transducer suitable for limited close range sensing to a 35 gram transducer that proved to be very effective in monitoring low pressure leaks into vacuum (typical of Space Shuttle cabin leaks). The 35 grams transducer could be reduced somewhat in weight but could not meet the 7 gram goal due to the crystal size.

A new flat contact sensor was designed for use in lightweight applications. The configuration shown in Figure No. 5 allows close coupling to the equipment under test while keeping a high resonant frequency for the basic transducer. This provides good response over the frequency range of the leak detection system as well as reasonably high sensitivity. As shown in the schematic the piezoelectric crystal, of diameter and thickness determined by the required sensitivity and free resonant frequency, is bonded to the bottom plate of the

holder but unrestrained at the edges. The top of the crystal is backed by a material having a much lower acoustic propagation velocity than the crystal or the holder, such as foam or in some cases, air. To keep the weight down as well as to minimize the height of the sensor, the cable is permanently attached to the holder. The transducer weight averages 3 grams while the cable and connector assemblies average 11 grams each.

3.11 CONCLUSIONS

In addition to the tests run at the Kennedy Space Center, numerous transducer and electronic development tests were performed in the Dynamatec facility. Tests were conducted on numerous valve seat configurations and tanks, pipes and fittings. From the results of the development tests and from the tests run at Kennedy Space Center, it appears that the ultrasonic contact sensor leak detection system is a very effective checkout and refurbishment tool for use on the Space Shuttle program. It has been demonstrated that the system will work on low pressure systems as well as high pressure systems and is practical for applications down to 10 to the minus 2 standard CCs per second. As was stated earlier, it is not a one system leak detection unit for all applications since it will not compete with a mass spectrometer down to the zero leakage level and it will not work as a hazardous gas detection unit. It is, however, a very effective tool and should be very beneficial in the checkout and refurbishment cycle for the Space Shuttle program. Applications have been identified for this system on the Rocketdyne Space Shuttle main engine valve and mounting pads are being designed into this engine.

One shortcoming of the ultrasonic contact sensor system, if it can be called a shortcoming, is that one general transducer will not meet all applications. Since the leak detection criteria varies greatly between internal valve seat leakages and external leakages in a large vehicle or pipe, it is advantageous and, in fact, necessary to design the transducer to each of these general applications if the 10 to the minus 2 standard CCs per second leak levels are to be obtained.

The ultrasonic contact sensor system delivered to NASA was designed for general test and evaluation purposes and can be utilized to provide the design information required for a flight system. For the flight system, the electronics would be modified and packaged in a more compact manner since spacecraft power and control would be utilized rather than the control unit furnished with the gear. The Dynamatec Corporation is continuing efforts in this area and is preparing the information necessary to fabricate a hybrid circuit for flight utilization. This hybrid circuit would contain the electronically controlled variable frequency filter and the necessary interface electronics to accept timing from a central timing source and to identify the data being sent to the data bus or central processor. A variable frequency filter was not a requirement of the Phase III contract but since it seemed that this system was necessary to achieve the final flight goals, the Dynamatec Corporation included a variable frequency filter in the deliverable hardware.

In addition to the applications on the Rocketdyne Space Shuttle engines, it is apparent from discussions with North American Rockwell personnel that it also has many potential applications on the space vehicle itself. Since the design goal of a 7 gram transducer was accomplished, in fact, lowered to a 5 gram transducer and since the electronics can be manufactured in hybrid circuits, an ultra light detection system is available for utilization on the Space Shuttle program. Preliminary estimates indicate that a 1 or 2 ounce total electronic and transducer system can be manufactured excluding cable weight. This would consist of a number of transducers, a similar number of preamplifiers, a hybrid chip consisting of a multiplexer, variable frequency filters and timing and data output circuits.

The next step in the application of the Dynamatec ultrasonic contact sensor system is to interface with the concerned contractors and their NASA counterparts to identify all potential applications of the leak detection system and to prove by laboratory and component testing which applications are truly justified for the flight vehicle. It appears that the time saved in checkout, the time saved in refurbishment and the trend or failure analysis data obtainable from such a system would make it a very worthwhile flight item.

APPENDICES
TEST REPORTS
SIMULATED SPACE CABIN LEAK DETECTION TEST

INTRODUCTION

On March 30, 1972, a simulated low pressure cabin leak detection test was conducted at the Kennedy Space Center. The test was conducted in one of the laboratory altitude chambers in the MSO building by the Dynamatec Corporation of Cocoa Beach, Florida. The test was performed under Contract NAS10-7803 - Study to Develop Improved Methods to Detect Leakage in Fluid Systems - Phase III.

Test Objective

The test objective was to determine if the ultrasonic contact sensor leak detection system being developed for NASA, KSC could be utilized for space cabin leak detection. The ability of the ultrasonic contact sensor system to detect low pressure space cabin leakage was not a design objective of the Phase III contract. It is being designed for leak detection of leaks in the 60 psi (420 kN/m^2) and above ranges but laboratory tests indicated it would also be effective at lower pressures.

A secondary test objective of the altitude chamber test was to demonstrate the capability of the ultrasonic contact sensor to detect higher pressure leaks in a typical spacecraft tank or piping system.

Test Setup

The test was performed in a Tenney thermal altitude chamber located in the NASA laboratories at the Kennedy Space Center. The test specimen was a thin walled steel pressure tank with a wall thickness of 0.0625 inches (1.6 mm). A valve is the top of the tank was left in the open position with a flex hose attached to the tank and to a bulkhead fitting through the chamber wall was attached to a 0 to 24 psi (0 to 165 kN/m^2) absolute pressure gauge and to two valves. One valve was used as a vent valve to allow air to enter the tank and a second valve was coupled to a vacuum pump which allowed the tank to be evacuated while it was in the altitude chamber. For the higher pressure leak detection tests in the altitude chamber, a nitrogen bottle was connected in place of the external vacuum pump (Figure No. 6).

The sample leak was generated by using a No. 80 drill. This produced a 0.0135 inch (0.3429 mm) diameter hole.

Two Phase III prototype transducers were attached to the tank wall with magnets. To assure good contact between the flat bottom transducers and the curved tank, an acrylic filler paste was utilized. The transducers were located at a distance of 45 cm from the leak. This was

the greatest distance that could be achieved with the diameter of tank being utilized. The transducer cables were coupled to bulkhead connectors in the chamber wall and the prototype electronics were located exterior to the chamber. Total cable length was approximately 1.8 meters between the electronics and the transducer.

Testing

Testing consisted of evacuating the chamber to a simulated altitude of 60,000 meters and then utilizing the external vacuum pump to evacuate the test tank. Following the evacuation of the test tank, the valve to the vacuum pump was closed and the vent valve was then utilized to increase the pressure in the test specimen as readings were taken with the contact sensor leak detection system. To provide a comparison between sea level and altitude readings, tests were conducted with the altitude chamber door open. Normal atmospheric tests have previously been conducted in the Dynamatec Corporation laboratory and the tests performed with the altitude chamber door open duplicated the laboratory results. Delta Ps as low as 1 psi (6.9 kN/m^2) provided strong signal readings from both transducers at sea level.

Test Results

The test results were plotted on Figure No. 7. With the same tank, the same hole and the same transducers it can be noted that while less than a Delta P of 1 psi (6.9 kN/m^2) was necessary at sea level, it required approximately 9 psi (62 kN/m^2) Delta P when a hole is vented to the 60,000 meter equivalent altitude chamber pressure before a signal was present. The signal strength increased rapidly for pressures above the 9 psi (62 kN/m^2) Delta P readings and as can be seen from Figure No. 1 a Delta P of 14 psi (97 kN/m^2) created a very strong signal. It was necessary to increase the pressure before a detectable signal was obtained from a smaller leak, created by partially closing the No. 80 hole. A third test was conducted in the altitude chamber which consisted of slightly cracking a pipe fitting at the top of the test tank. From the pressure built up in the altitude chamber with the chamber pumps shut off, it is estimated that the cracked fitting leak was approximately equivalent to the No. 80 hole. This leak generated a much stronger signal which is attributed to the path that the gas molecules had to take prior to entering the altitude chamber. While the gas molecules escaped directly into the chamber through the No. 80 hole they were required to pass over a number of threads prior to escaping from the cracked fitting.

An interesting side note to the test was that the transducers were not affected by the altitude chamber pumps neither at sea level or at altitude. Since the pumps were located in close proximity to the tank and since the tank was connected to the chamber wall by plumbing, this provided a very encouraging background interference test.

Conclusions

It can be concluded from the test results that the ultrasonic contact sensor leak detection system can be utilized for space cabin leak detection for Delta Ps above 9 psi (62 kN/m^2). Since the Space Shuttle cabin is to be pressurized in the 14 psi (97 kN/m^2) range, this would be an effective tool for detecting leaks ranging from somewhere below 0.0135 inch (.343 mm) diameter and upwards. To establish the full capability of this instrument, a more elaborate chamber test is required.

It also can be concluded that the ultrasonic contact sensor leak detection system is an effective tool for leak detection in higher pressure plumbing systems such as those to be utilized on the Space Shuttle. Further altitude chamber tests are planned on the high pressure system to demonstrate the capability of the instrument to meet design objectives.

Test Setup

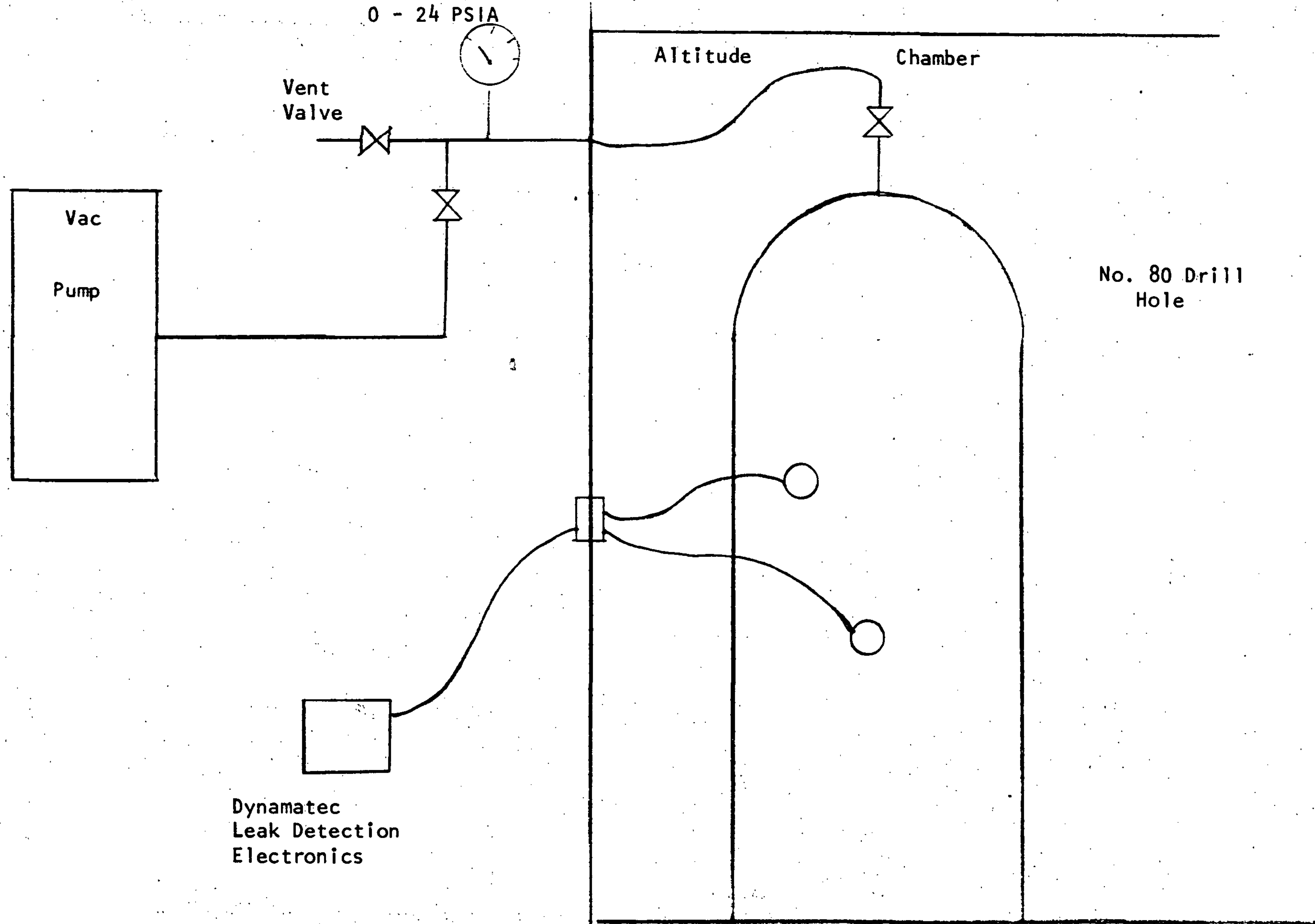


FIGURE NO. 6

DYNAMATEC CORPORATION
4/5/72

Altitude Chamber Test
3/30/72

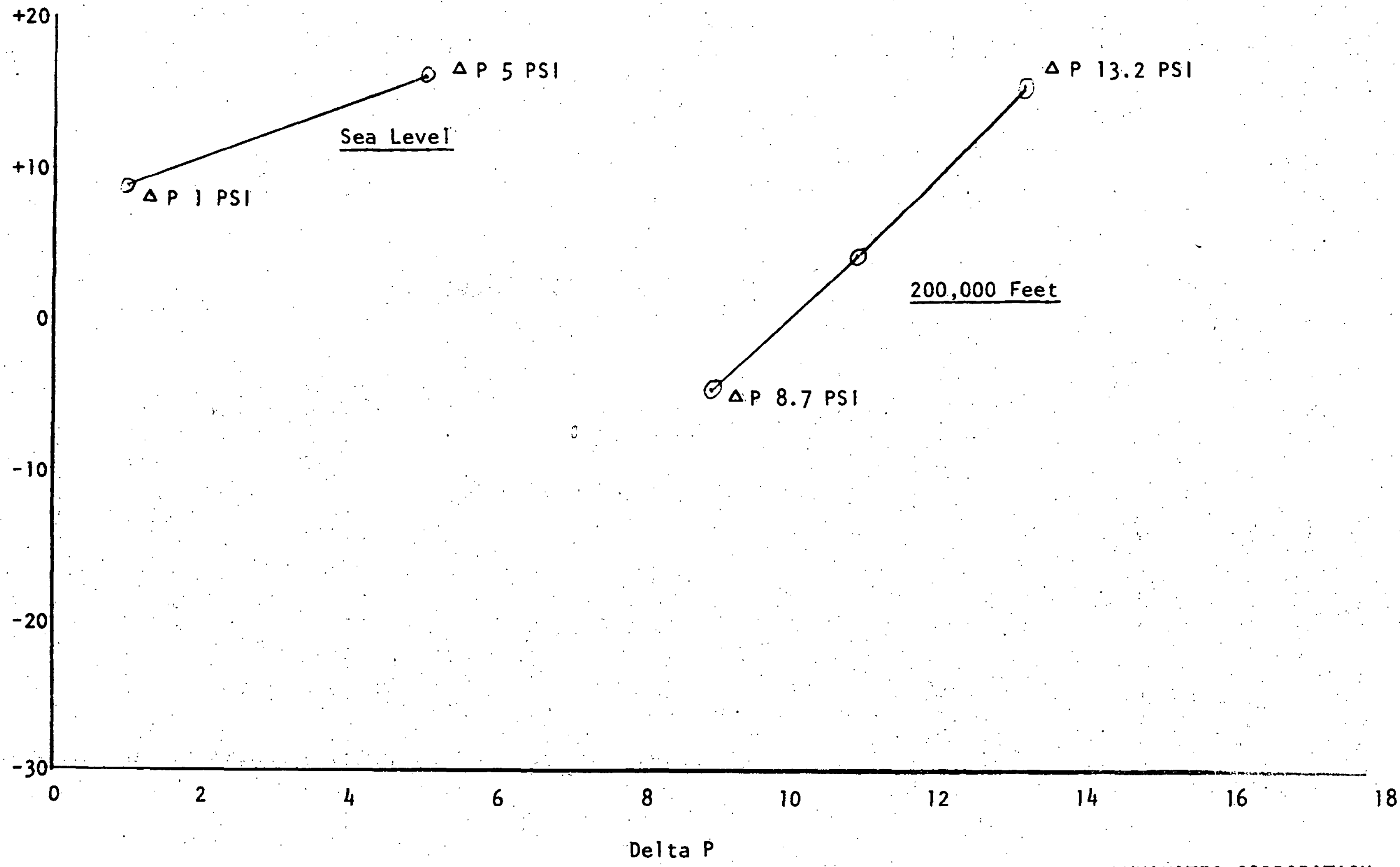


FIGURE NO. 7

DYNAMATEC CORPORATION
4/5/72

22

Environmental Test On the Dynamatec

Ultrasonic Contact Sensor Leak

Detection System

On July 11, 1972, three ultrasonic contact sensors were tested in the Tenney altitude chamber at KSC at temperatures ranging down to -68 degrees Centigrade. The three transducers were mounted on a Marotta valve Model MB 74. This is an electrical solenoid valve with three flow passages. For the test, the leak was established by manually adjusting the seat to allow nitrogen to leak through. The purpose of the test was to establish what, if any, drop in signal level would be received as the temperature chamber was reduced. A constant flow was established through the valve seat and readings were taken at ambient temperatures in steps ranging down to -68 degrees Centigrade. The valve assembly was allowed to cold soak at various steps of the procedure to assure that the temperature had stabilized throughout the valve body and transducer assembly.

One of the transducers utilized for this test was a model of the deliverable unit and the second was a larger transducer used as a standard. Following the completion of the environmental temperature tests with the temperature at -68 degrees Centigrade, the chamber was evacuated to an equivalent altitude of 54,000 meters. All of the tests indicated that both transducers were capable of operating down to the lower temperature limit capability of the altitude chamber or in the -100 degree (-70° C) Fahrenheit range. Some signal level changes were noted as the temperature was lowered, but appeared to be caused more by changing characteristics of the valve seat than in the sensing capability of the transducers. These changes were of a minor nature and would not affect the leak detection capability of the ultrasonic systems. When the chamber was taken to altitude, there was a major increase in the signal level which was caused by a greater delta P across the valve seat. This one atmosphere of delta P increase was a major change to the basic 40 psi (275 kN/m^2) nitrogen pressure on the valve thereby greatly increasing the leak rate and the signal strength.

Following the cold soak and altitude chamber tests, a fourth transducer was attached to the ultrasonic contact sensor electronic package and the transducer was then lowered into a liquid nitrogen bath. This was a severe shock treatment which would not normally occur due to the time lage associated with cryogenic temperatures penetrating a valve or pipe wall. However, the transducer was not affected in any way. The transducer was dropped from a temperature of approximately 76 degrees (24.4° C) Fahrenheit to a temperature of -320 degrees (-196° C) Fahrenheit by completely submering it in liquid nitrogen; therefore, it is felt that under normal operating conditions the transducer is capable of being used below these temperatures. The prototype transducers

produced during the Phase II contract were utilized on their liquid hydrogen lines by the exact temperature at the transducer case was not known. The test setup was not conducive to a signal level test at the liquid nitrogen temperature but a general sensitivity test was conducted immediately upon withdrawal of the transducer and little, if any, sensitivity loss was noted. A more elaborate cryogenic test setup on typical spacecraft valve is required to fully evaluate the potential of the Ultrasonic Contact Sensor Leak Detection System, but the tests run in the KSC altitude chamber and with the liquid nitrogen bath indicated that low temperature operation is practical for this system.

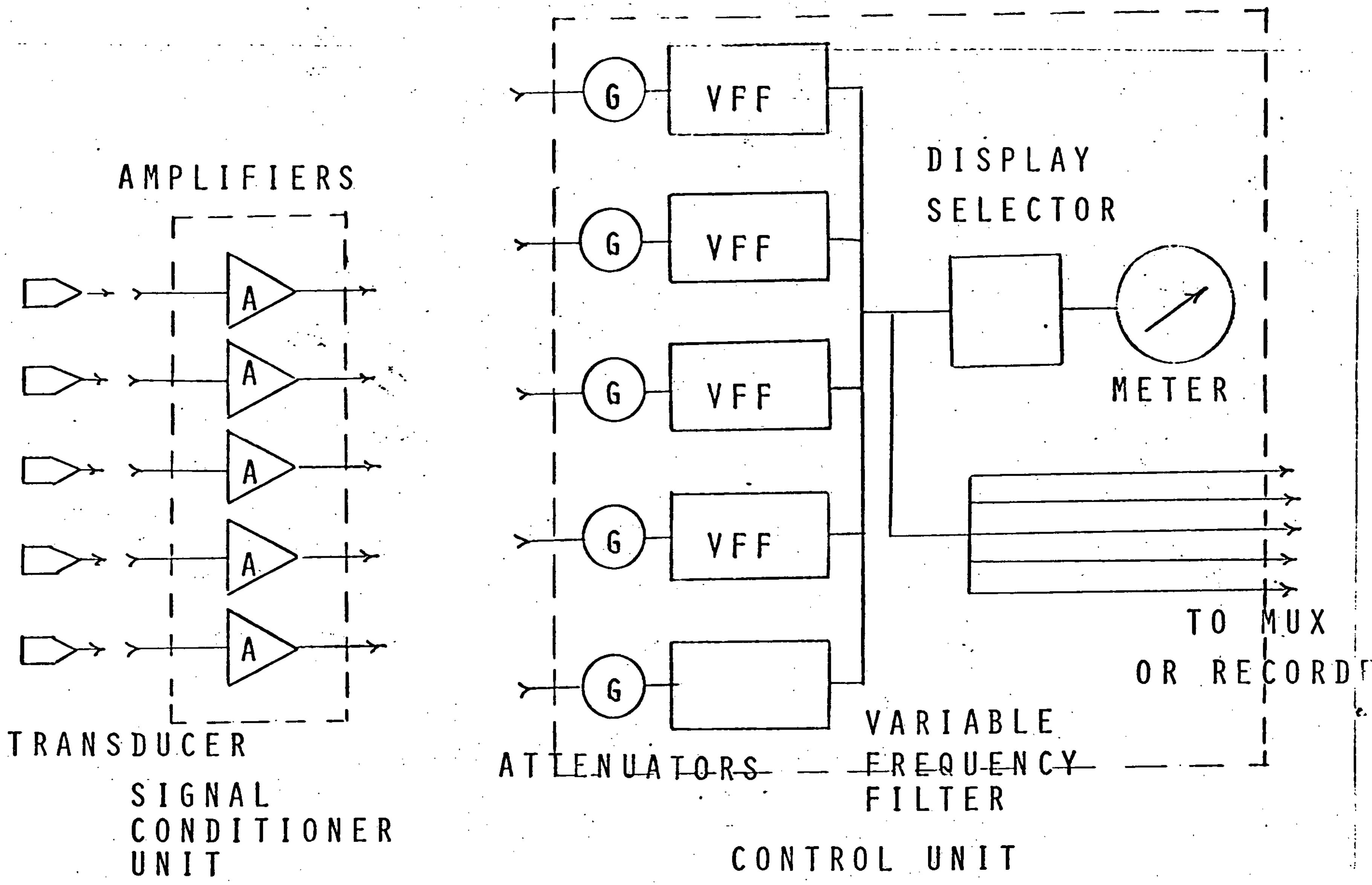
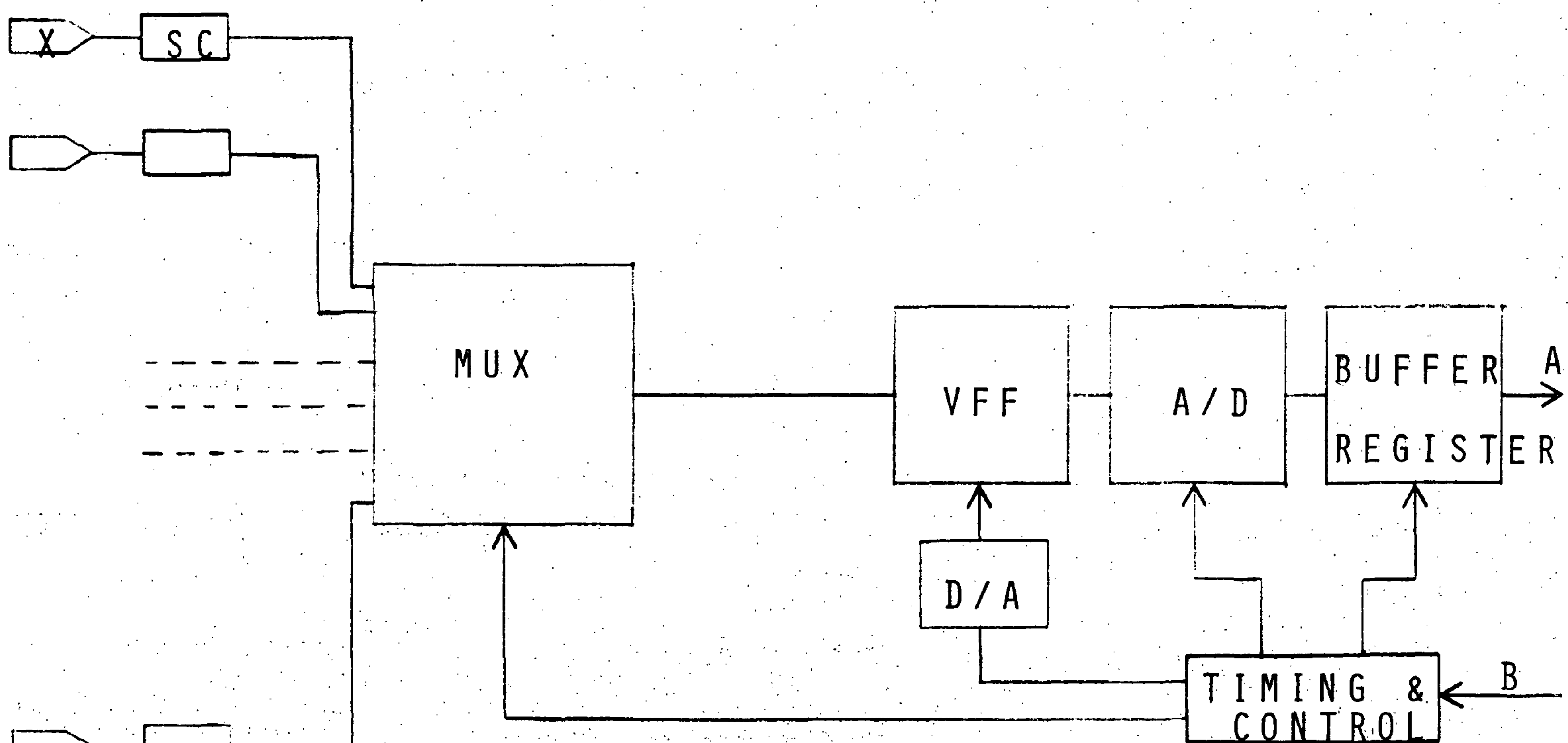


FIGURE 1

DYNAMATEC CORPORATION

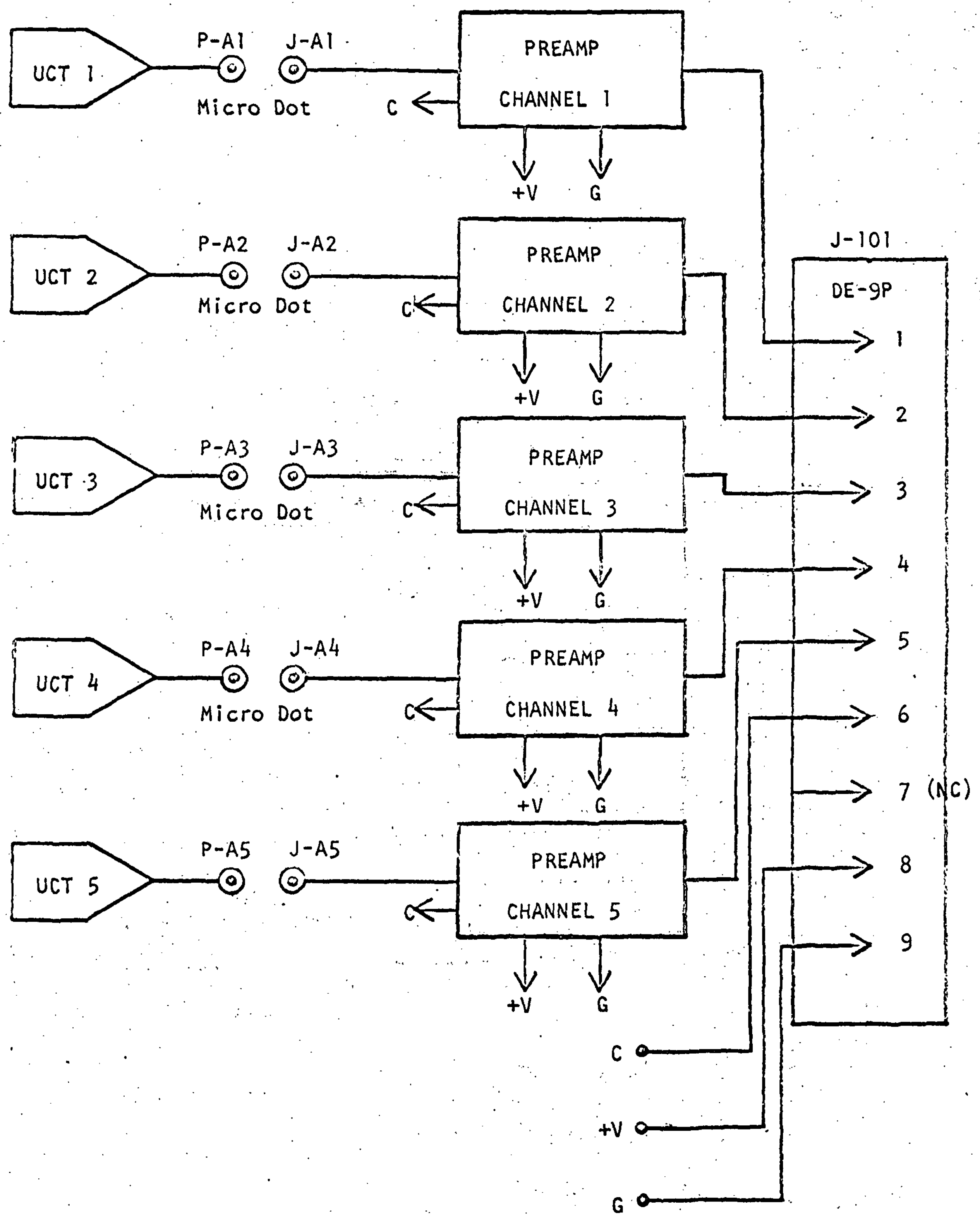
FLIGHT CONFIGURATION

ULTRASONIC LEAK DETECTOR



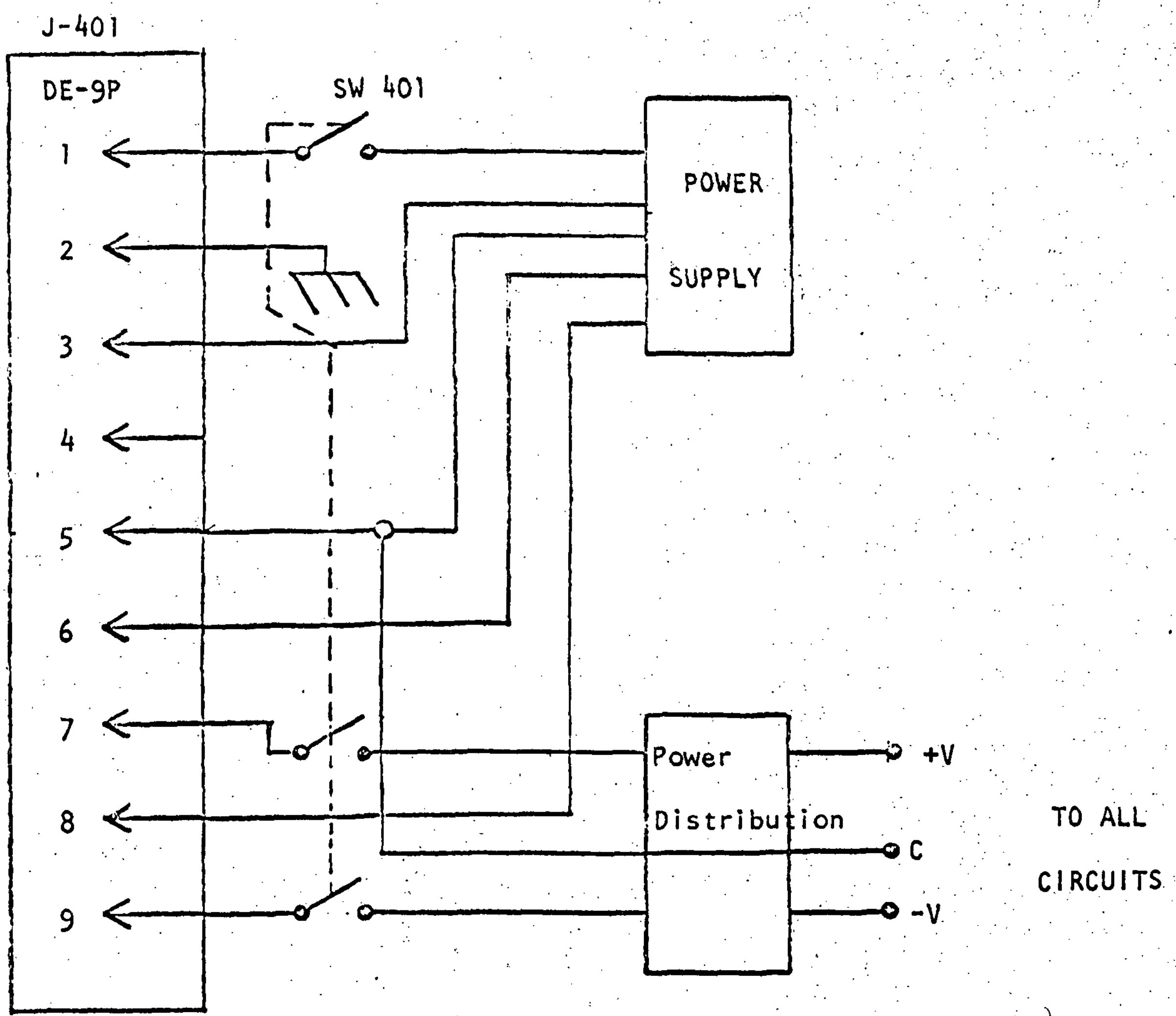
A. TO CENTRAL PROCESSOR
B. FROM CENTRAL PROCESSOR

FIGURE NO. 2



PREAMPLIFIER

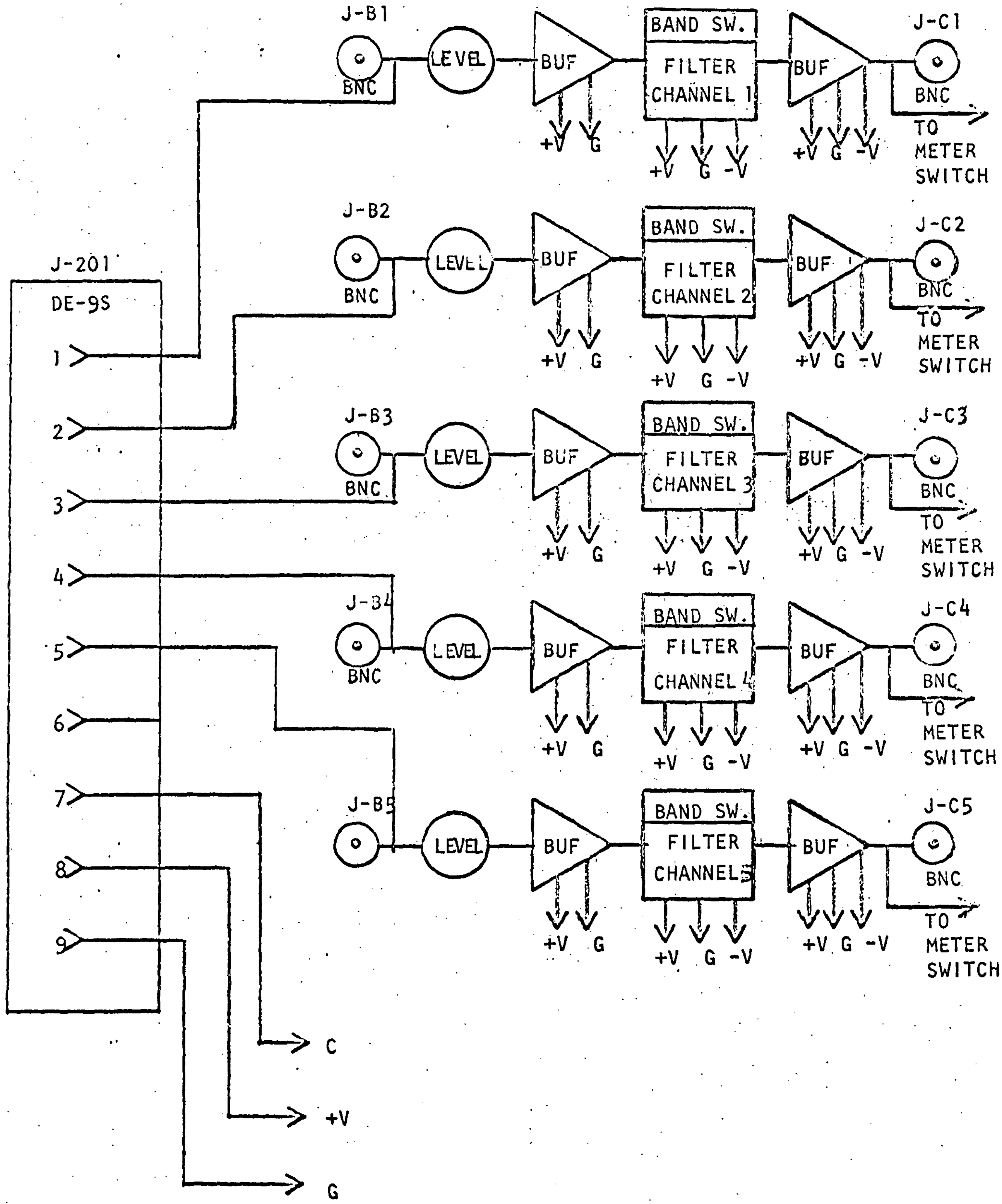
FIGURE NO. 3



CONTROL UNIT

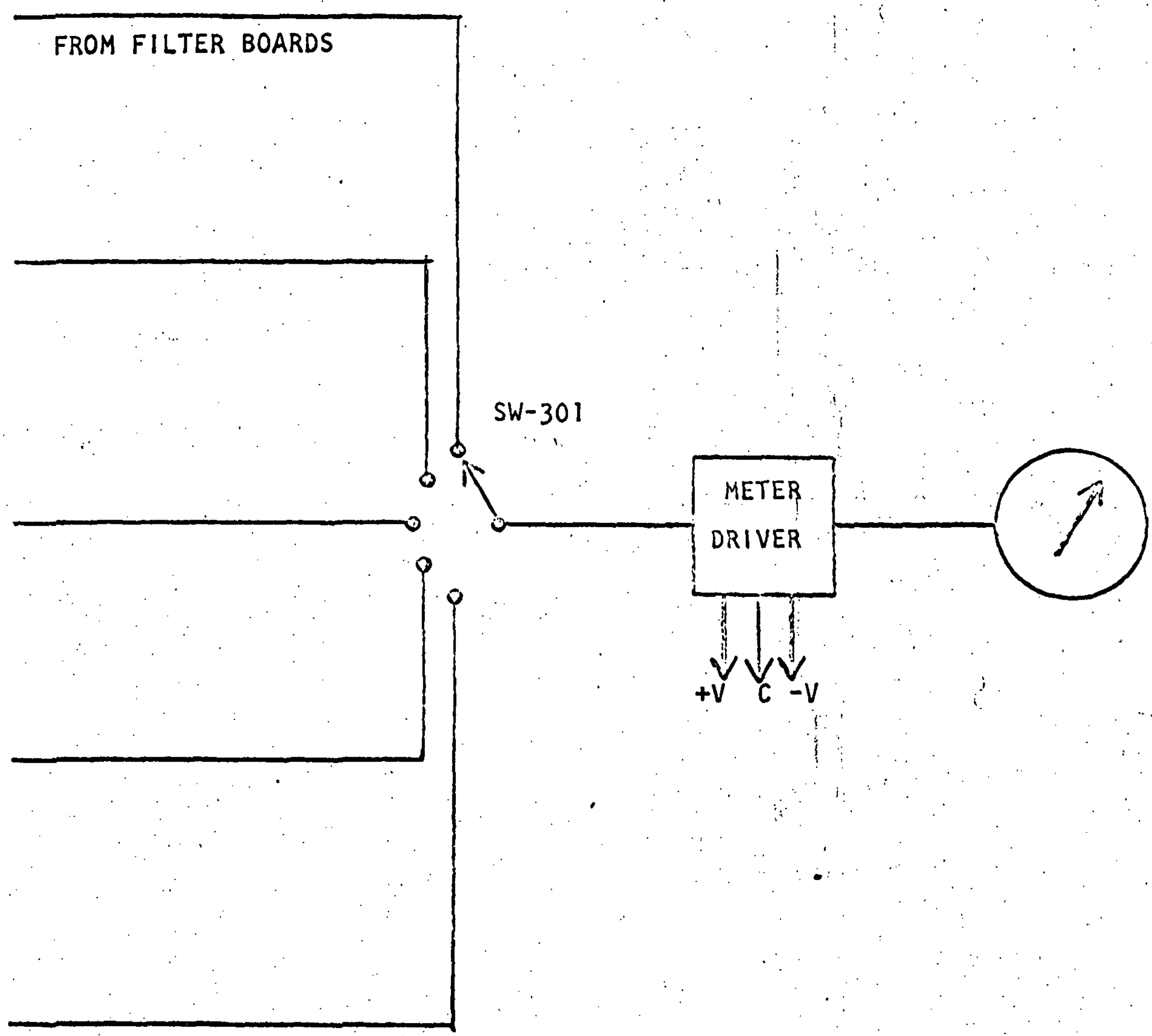
POWER SUPPLY

FIGURE NO. 4a



CONTROL UNIT

FIGURE NO. 4b



CONTROL UNIT

FIGURE NO. 4c

DOCUMENT RELEASE AUTHORIZATION

KENNEDY SPACE CENTER
NASA

DRA REVISION			DRA NO. S-00KS01-169	
REV NO.	DATE	APPROVAL	NEED DATE NA	SHEET 1 OF 3
			SYSTEM NA	
			REL ON NA	
			PCN NO. NA	
			EFFECTIVITY	

DOCUMENT DISTRIBUTION

QUAN.	TO	NAME	QUAN.	TO	NAME
1	DE	G. Williams	2	DD-EDD-22	P. Rogers
1	DD	D. Buchanan	2	DD-EDD-22	J. Johnson
1	FP	F. Merritt Preston	1	SO-LAB	R. Yorio
1	FP	A. Pickett	1	SO-LAB-1	T. Lamontagne
2	FP-A	S. Beddingfield	1	SO-LAB-3	J. Larson
1	FP-A	J. Spears	1	SO-ENG-4	H. McCluer
1	FP-A	R. Smith	1	SO-ENG-4	R. Laakso
1	FP-B	H. McCoy	1	LS-ENG-3	F. Williams
2	FP-C	R. Cerrato	1	LS-ENG-3	H. Lamberth
1	SF	J. Atkins	1	LS-ENG-31	W. Lackie
1	DD-MDD	A. Zeiler	1	LS-ENG-32	D. Moxley
1	DD-MDD-1	W. Clautice	1	LS-ENG-32	S. Ewing
1	DD-MDD-3	E. Davis	1	LS-TEC	W. Risler
20	DD-MDD-32	B. Tolson	2	AD-PAT	J. Harrell
1	DD-SED-4	A. Carraway	1	AD-PRO-33	W. Howard
1	DD-SED-4	P. Toft	1	LV-MEC-32	E. Dickinson
2	DD-SED-4	R. Sannicandro	1	LV-GDC-28	J. Jamieson
1	DD-SED-4	J. Deese	1	LV-GDC-3	C. Whiteside

DOCUMENTS

	SIZE	DOCUMENT NUMBER	SHEETS	ISSUE	WAS	SIZE	DOCUMENT NUMBER	SHEETS	ISSUE	WAS
**	A	TR-1198	32	New	-					

REMARKS: Documentation Only - No MIP REQUIRED

PREPARED BY	DATE	DESIGN APPROVAL	DATE
SYSTEMS ASSURANCE APPROVAL	DATE	RELEASE APPROVAL John K Hooker	DATE 9-28-72

KSC FORM 21-68 (REV. 5/71) NASA/PAFB JAN/72

DOCUMENT RELEASE AUTHORIZATION

KENNEDY SPACE CENTER
NASA

DRA REVISION			
REV NO.	DATE	APPROVAL	

DRA NO. S-00KS01-169

NEED DATE NA — SHEET 2 OF 3

SYSTEM NA

REL ON NA

PCN NO. NA

EFFECTIVITY

DOCUMENT DISTRIBUTION

QUAN.	TO	NAME	QUAN.	TO	NAME
1	LV-GDC-3	F. Penovich		LIBRARIES	
1	LV-INS-22	W. Helms	2	A&TS-MS-IL	MSFC Technical
1	IN-MSD-2	R. Upson	3	IS-CAS-42C	KSC Documents
1	TS-TSM	R. Brooks			
				NASA HDQ	
	MSFC		1	DY	M. Shaw
1	PD-MP-T	H. Craft	1	MHE	R. Liningston
6	SNE-ASTR-SE	W. Voss			
1	ASTR-IM	W. Escue		CONTRACTORS	
1	PD-RV-MGR	R. Godfrey	1	ROC-5	F. Mosby
2	S&E-ASTN-X	J. Thompson		Rocketdyne	
3	S&E-ASTN-PES	D. Rodgers	1	GE-AGS	D. Kitchel G.E.
			1	JPL	R. Weiner
	MSC			MS 2333-103	
2	LA	R. Thompson		4800 Oak Grove Dr.	
1	ND-5	J. Maxwell		Pasadena, CA 91103	
			1	Space Div, NAR	C. Janka
				MS AD-75	

DOCUMENTS

1214 Lakewood Blvd, Downey, CA 9024

SIZE	DOCUMENT NUMBER	SHEETS	ISSUE	WAS	SIZE	DOCUMENT NUMBER	SHEETS	ISSUE	WAS

REMARKS:

PREPARED BY	DATE	DESIGN APPROVAL	DATE
SYSTEMS ASSURANCE APPROVAL	DATE	RELEASE APPROVAL	DATE

DOCUMENT RELEASE AUTHORIZATION

KENNEDY SPACE CENTER
NASA

DRA REVISION				
REV NO.	DATE	APPROVAL	DRA NO.	S-00KS01-169
			NEED DATE	NA — SHEET 3 OF 3
			SYSTEM	NA
			REL ON	NA
			PCN NO.	NA
			EFFECTIVITY	

DOCUMENT DISTRIBUTION

QUAN.	TO	NAME	QUAN.	TO	NAME
12		J. Janus Dynamatec Corp Cocoa Beach, Fla	1		Lewis Research Center Don Forney MS 6-2 21000 Brookpark Rd. Cleveland, Ohio 44135
3		NASA Scientific & Technical Information Facility P.O. Box 33 College Park, Maryland	1		Langley Station Victor L. Vaughan MS 188B Hampton, Va. 23365
3		NASA Headquarters New Technology Representative Code UT Washington, D. C. 20546			
1		NASA-MSC Bill Andrews MS PB82 Bethpage, N.Y.			

DOCUMENTS

SIZE	DOCUMENT NUMBER	SHEETS	ISSUE	WAS	SIZE	DOCUMENT NUMBER	SHEETS	ISSUE	WAS

REMARKS:

PREPARED BY	DATE	DESIGN APPROVAL	DATE
SYSTEMS ASSURANCE APPROVAL	DATE	RELEASE APPROVAL	DATE

FLAT MINIATURE CONTACT SENSOR

STAINLESS STEEL CASE

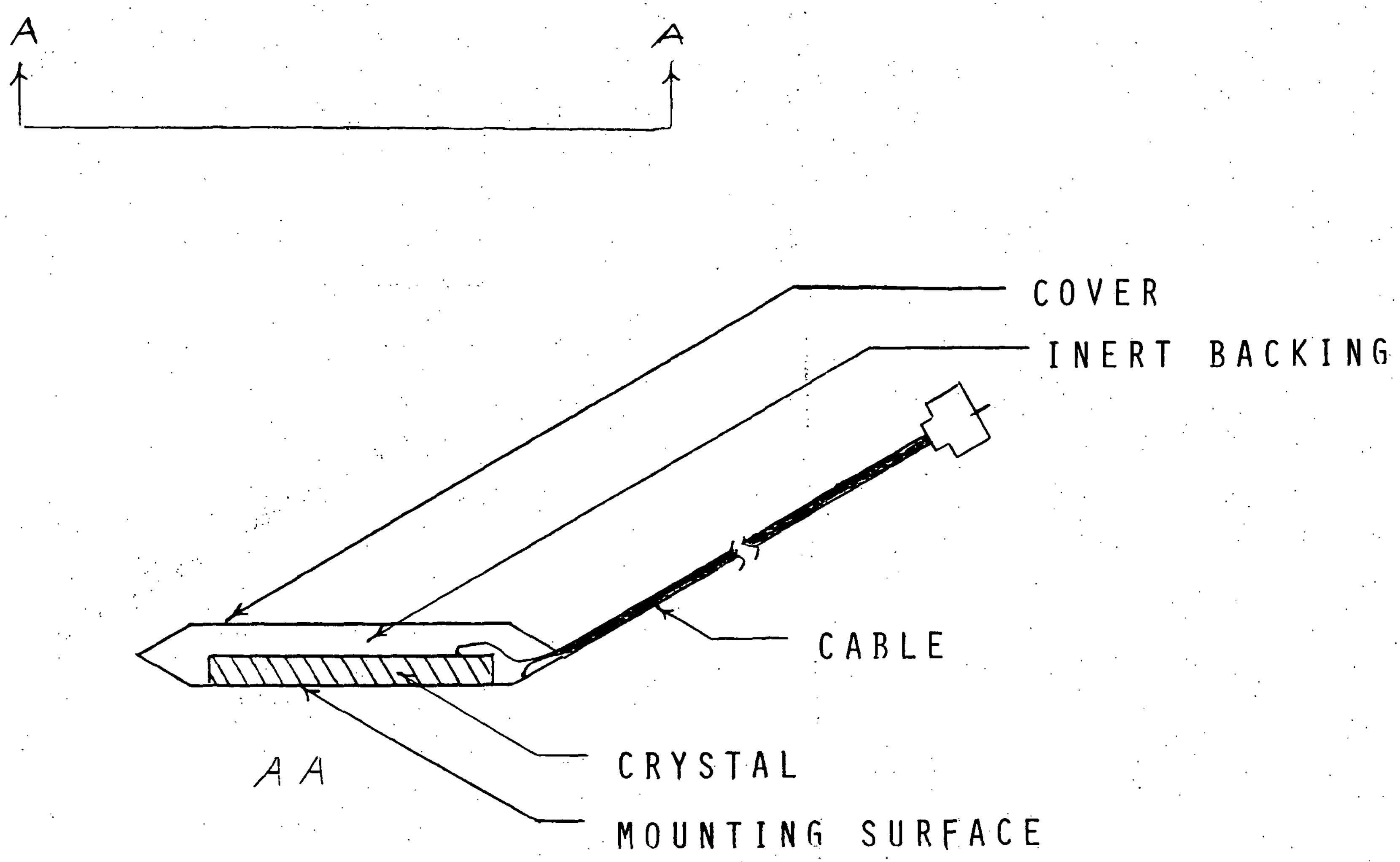


FIGURE NO. 5

DISTRIBUTION

KSC

G. Williams	DE	1
D. Buchanan	DD	1
G. Merritt Preston	FP	1
A. Pickett	FP	1
S. Beddingfield	FP-A	2
J. Spears	FP-A	1
R. Smith	FP-A	1
H. McCoy	FP-B	1
R. Cerrato	FP-C	2
J. Atkins	SF	1
A. Zeiler	DD-MDD	1
W. Clautice	DD-MDD-1	1
E. Davis	DD-MDD-3	1
B. Tolson	DD-MDD-32	20
A. Carraway	DD-SED-4	1
P. Toft	DD-SED-4	1
R. Sannicandro	DD-SED-4	2
J. Deese	DD-SED-4	1
P. Rogers	DD-EDD-22	2
J. Johnson	DD-EDD-22	2
R. Yorio	SO-LAB	1
T. Lamontagne	SO-LAB-1	1
J. Larson	SO-LAB-3	1
H. McCluer	SO-ENG-4	1
R. Laakso	SO-ENG-4	1
F. Williams	LS-ENG-3	1
H. Lamberth	LS-ENG-3	1
W. Lackie	LS-ENG-31	1
D. Moxley	LS-ENG-32	1
S. Ewing	LS-ENG-32	1
W. Risler	LS-TEC	1
J. Harrell	AD-PAT	2
W. Howard	AD-PRO-33	1
E. Dickinson	LV-MEC-32	1
J. Jamieson	LV-GDC-28	1
C. Whiteside	LV-GDC-3	1
F. Penovich	LV-GDC-3	1
W. Helms	LV-INS-22	1
R. Upson	IN-MSD-2	1
R. Brooks	TS-TSM	1

MSFC

H. Craft	PD-MP-T	1
W. Voss	SNE-ASTR-SE	6
W. Escue	ASTR-IM	1
R. Godfrey	PD-RV-MGR	1
J. Thomson	S&E-ASTN-X	2
D. Rodgers	S&E-ASTN-PES	3

MSC

R. Thompson	LA	2
J. Maxwell	ND-5	1

LIBRARIES

MSFC Technical	A&TS-MS-IL	2
KSC Documents	IS-CAS-42C	3

NASA HDQ

M. Shaw	DY	1
R. Livingston	MHE	1

CONTRACTORS

F. Mosby ROC5	Rocketdyne	1
D. Kitchel GE-AGS	G.E.	1
R. Weiner	JPL MS 2333-103 4800 Oak Grove Dr. Pasadena, CA 91103	1
C. Janka	Space Div. NAR MS AD-75 1214 Lakewood Bld Downey, CA 90241	1
J. Janus	Dynamatec Corp. Cocoa Beach, Fla.	12

OTHER GOVERNMENT FACILITIES

NASA Scientific & Technical Information Facility P.O. Box 33 College Park, Maryland 20740	3
NASA Headquarters New Technology Representative Code UT Washington, D.C. 20546	3
NASA-MSC Bill Andrews MS PB82 Bethpage, N.Y.	1
Lewis Research Center Don Forney MS 6-2 21000 Brookpark Rd. Cleveland, Ohio 44135	1
Langley Station Victor L. Vaughan MS 188B Hampton, Va. 23365	1

TOTAL COPIES 114